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Bureau of Mines
Department of Natural Resources
State of Maryland
Maryland

WATER QUALITY STUDIES OF PORTAGE CREEK IN KALAMAZOO COUNTY 1968 AND 1970

Michigan Water Resources Commission

Bureau of Water Management

Department of Natural Resources

State of Michigan

May 1972

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INTRODUCTION

The Michigan Water Resources Commission adopted quality standards for inland waters on January 4, 1968. A portion of these standards designate the particular use or uses for which a stream or lake sector will be protected. The intent of the standards program is both to protect existing desirable use and to improve the quality of water where it does not now support desirable use consistent with Michigan Act 245, Public Acts of 1929, as amended.

Portage Creek, a tributary of the Kalamazoo River, has been degraded by industrial wastes as it passed through the cities of Portage and Kalamazoo. Improvements and changes in wastewater treatment at various industries have recently improved water quality in Portage Creek.

Intensive water quality surveys of the lower three miles of Portage Creek were conducted in the summers of 1968 and 1970. The purpose of these studies was to determine the quantity and strength of waste discharges to the creek and to determine the severity of chemical, physical, and bacteriological degradation caused by these waste discharges. This data was then used to determine the additonal restrictions necessary to adequately protect the designated uses of Portage Creek. In addition to restrictions intended to protect existing use designations, calculations were also made to determine restrictions if the use designations of the creek from Cork Street in Kalamazoo to its mouth were upgraded from the existing Warm Water Tolerant Fish use designation to a Warm Water Intolerant Fish use designation.

SUMMARY

1. Portage Creek has had a history of water quality degradation from industrial waste discharges. These have affected not only the entire reach of the creek below these discharges, but have also added to degradation of the Kalamazoo River.

2. Changes in wastewater treatment practices at the Upjohn Company and the Georgia-Pacific Corporation Paper Converted Products Plant protect the water quality of the upper portions of Portage Creek to satisfactory levels. Improvements and changes in wastewater treatment at the Allied Paper Corporation Monarch and Bryant Mills and at the Cadillac Plastic and Chemcial Company have recently improved water quality in the lower portion of Portage Creek.

3. Water quality investigations of the lower portion of the stream were conducted in August 1968 and in September 1970. Data indicated severe water quality degradation in 1968 for the entire reach of Portage Creek below the Allied Paper Corporation (Cork Street to the mouth). In contrast, in 1970, after deinking and chlorine bleach wastes were diverted to the City of Kalamazoo sewerage system, the water quality in Portage Creek substantially improved.

4. Except for the Bryant millpond, the water quality of Portage Creek in September 1970 was satisfactory to meet the criteria of Michigan's Intrastate Water Quality Standards for the designated uses of Portage Creek. Dissolved oxygen concentrations in the millpond were not adequate to protect current designated uses.

5. To adequately maintain dissolved oxygen concentrations at specified (10 - year recurrence of minimum low flow of 7 - day duration) drought flow conditions, it will be necessary to reduce the discharge of biochemical oxygen demanding substances from the Allied Paper Corporation.

6. Upgrading of the existing Warm Water Tolerant Fish use designation to a Warm Water Intolerant Fish use designation would require even more substantial reductions in discharges of biochemical oxygen demanding substances.

BASIN DESCRIPTION

Portage Creek is a small tributary of the Kalamazoo River, draining approximately 55 square miles of Texas Township, the City of Portage and the City of Kalamazoo. Its headwaters are in eastern, central Texas Township, in the Gourdneck State Game Area. The creek flows east into Portage, passing through Hampton Lake, and then flows north into Kalamazoo. The West Fork of Portage Creek has its headwaters in Scouters Pond, located in the center of Texas Township. It flows northeast, passing through Atwater Millpond and Limekiln Lake, and then east, roughly paralleling the Portage - Kalamazoo boundary, until it joins Portage Creek just inside Kalamazoo. This portion of the Creek passes through residential areas and parks. Upstream from Cork Street and also upstream from Alcott Street low head dams form small impoundments, the Monarch millpond and the Bryant millpond. Industrial development is found along this portion of the creek. From Reed Avenue to East Walnut Street the creek continues north through residential, commercial, and park areas within Kalamazoo. The last three quarters of a mile of Portage Creek passes through a basically industrial area. It joins the Kalamazoo River just east of the central business district of Kalamazoo. (See Figure 1).

DESIGNATED USES OF PORTAGE CREEK

Intrastate Water Quality Standards, intended to protect and enhance the quality of Michigan's inland waters, were adopted by the Water Resources Commission on January 4, 1968. The standards include specific limits on water quality parameters and desiganted water uses to be protected in particular lakes and reaches of streams and rivers. Where multiple use classifications exist, the most restrictive limits on parameters apply. Water which does not meet the standards at all stream flows equal to or exceeding the 10-year recurrence of minimum low flow of 7-day duration will be improved to meet the standards.

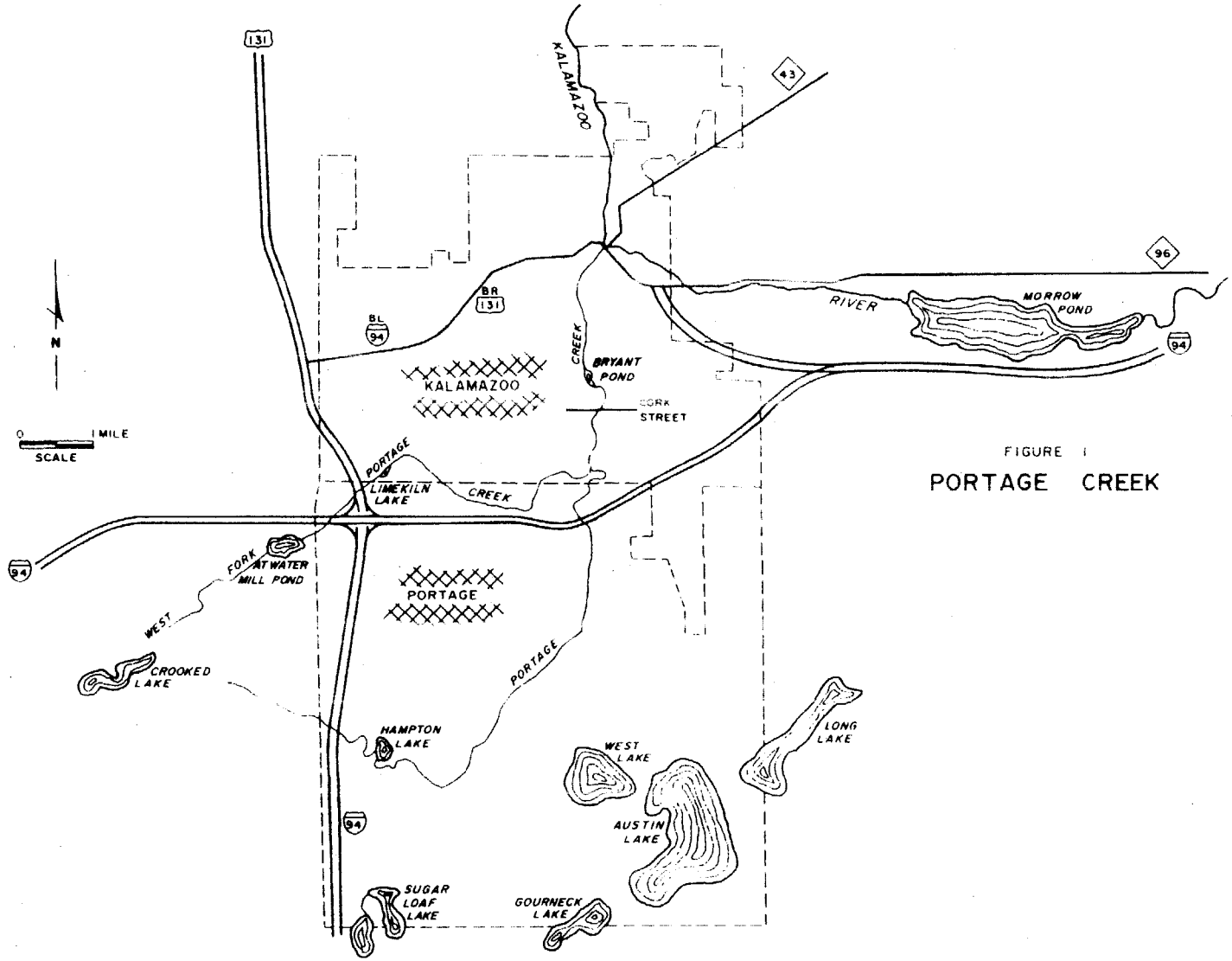


FIGURE 1

PORTAGE CREEK

The presently adopted uses for various reaches of Portage Creek are:

Industrial Water Supply - (manufacturing processes other than food processing) - Entire creek.

Recreation - Partial Body Contact - (hunting, fishing, boating, etc.) - Entire creek.

Fish, Wildlife, and Other Aquatic Life - Intolerant Fish, Warmwater Species - (bass, pike, panfish, etc.) - Entire creek upstream from Cork Street in Kalamazoo.

Fish, Wildlife, and Other Aquatic Life - Tolerant Fish, Warmwater Species - (carp, bullheads, etc.) - Entire creek downstream from Cork Street in Kalamazoo to its confluence with the Kalamazoo River.

Agricultural - (irrigation, stock watering, etc.) - Entire creek.

The Tolerant Fish, Warm-Water Species use designation for the lower portion of the stream will apply only until January 1974 by which time the waste disposal situations involved are to have been placed before the Water Resources Commission for critical reconsideration, with a view toward the application of higher quality use designations.

The limits on specific water quality parameters for various designated uses are shown in Table I.

WASTE DISCHARGES TO PORTAGE CREEK

Upjohn Company

This large pharmaceutical firm is located in Portage. Since 1954 certain strong wastes from antibiotics manufacture have been pretreated and injected into the Traverse and Monroe underground formations by two deep wells located on the company's property. The Water Resources Commission by Order of Determination requires that the quantities injected not exceed 300,000 gallons per day (gpd); that casing head pressures not exceed 1,250 pounds per square inch; and that the company report to the Commission at least once every six months showing quantities of waste disposal, waste injection pressures, pH of the waste, and any unusual conditions which develop in the underground waste disposal program. Solvents and certain other organic compounds are incinerated.

Sanitary and less concentrated process wastes were given secondary treatment in trickling filters, disinfected, and the final effluent was discharged to Portage Creek. In June, 1967 these liquid wastes were connected to the City of Kalamazoo sewerage system, thus eliminating this discharge to Portage Creek.

A portion of their cooling and storm water is still discharged to Portage Creek. The quantity of cooling water and its temperature, are determined daily by the company and monthly operating reports, containing this information, are sent to the Bureau of Water Management. For the last half of 1971, the average

COMMISSION OBJECTIVE:

WATERS IN WHICH THE EXISTING QUALITY IS BETTER THAN THE ESTABLISHED STANDARDS ON THE DATE WHEN SUCH STANDARDS BECOME EFFECTIVE WILL NOT BE LOWERED IN QUALITY BY ACTION OF THE WATER RESOURCES COMMISSION UNLESS AND UNTIL IT HAS BEEN AFFIRMATIVELY DEMONSTRATED TO THE MICHIGAN WATER RESOURCES COMMISSION THAT THE CHANGE IN QUALITY WILL NOT BECOME INJURIOUS TO THE PUBLIC HEALTH, SAFETY, OR WELFARE, OR BECOME INJURIOUS TO DOMESTIC, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL OR OTHER USES WHICH ARE BEING MADE OF SUCH WATERS, OR BECOME INJURIOUS TO THE VALUE OR UTILITY OF RIPARIAN LANDS; OR BECOME INJURIOUS TO LIVESTOCK, WILD ANIMALS, BIRDS, FISH, AQUATIC LIFE OR PLANTS, OR THE GROWTH OR PROPAGATION THEREOF BE PREVENTED OR INJURIOUSLY AFFECTED; OR WHEREBY THE VALUE OF FISH AND GAME MAY BE DESTROYED OR IMPAIRED, AND THAT SUCH LOWERING IN QUALITY WILL NOT BE UNREASONABLE AND AGAINST PUBLIC INTEREST IN VIEW OF THE EXISTING CONDITIONS IN ANY INTRASTATE WATERS OF MICHIGAN.

WATER WHICH DOES NOT MEET THE STANDARDS WILL BE IMPROVED TO MEET THE STANDARDS.

PARAMETERS / USES	1 COLIFORM GROUP (organisms/100ml or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A **WATER SUPPLY** (1.) **DOMESTIC** Such as drinking, culinary and food processing.	The monthly geometric average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating Solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l. Chromium6: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-8.
(2.) **INDUSTRIAL** Such as cooling and manufacturing process.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
B **RECREATION** (1.) **TOTAL BODY CONTACT** Such as swimming, water skiing and skin diving.	The geometric average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 100.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
(2.) **PARTIAL BODY CONTACT** Such as fishing, hunting, trapping and boating.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
C **FISH, WILDLIFE AND OTHER AQUATIC LIFE** such as (growth and propagation)	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	At the average low flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained in rivers capable of supporting: Intolerant fish, coldwater species (trout, salmon) - Not less than 6 at any time; Intolerant fish, warmwater species (bass, pike, panfish) - Average daily DO not less than 5, nor shall any single value be less than 4; Tolerant fish (carp, bullheads) - Average daily DO not less than 4, nor shall any single value be less than 3; Principal anadromous fish migrations in warmwater rivers - Not less than 5 during migrations.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency.
D **AGRICULTURAL** Such as livestock watering, irrigation and spraying.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	At greater flows the DO shall be in excess of these values. For lakes see discussion, page 26 — Not less than 3 at any time.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use.
E **COMMERCIAL AND OTHER** Such as navigation, hydroelectric and steam generated electric power and use of [illegible]	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000	Average daily not less than 7.5, nor any single value less than 7.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.

TABLE 1

QUALITY STANDARDS

6 TOTAL DISSOLVED SOLIDS (mg/l)	7 NUTRIENTS Phosphorus, ammonia, nitrates and sugars	8 TASTE & ODOR PRODUCING SUBSTANCES	9 TEMPERATURE (°F)	10 HYDROGEN ION (pH)	11 RADIOACTIVE MATERIALS
Total Dissolved Solids: Shall not exceed 500 as a monthly average, nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 75, nor shall any single value exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.002 mg/l - maximum concentration limited to 0.005 mg/l for a single sample.	The maximum natural water temperature shall not be increased by more than 100F.	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 100F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Standards to be established when information becomes available on deleterious effects.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taint in the flesh of fish or game.	In rivers capable of supporting: Ambient / Allowable increase / Maximum limit Intolerant fish, cold-water species (trout): 32° to nat. max. / 10° / 70° Intolerant fish, warm-water species (bass): 32° to 35° / 36° to nat. max. / 15° / 10° / 85° Tolerant fish, warm-water species (carp): 32° to 59° / 60° to nat. max. / 15° / 10° / 87° For anadromous fish migrations and inland lakes see discussion, page 29	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0.).	Standards to be established when information becomes available on deleterious effects.
Less than 75% dissolved minerals. Maximum percentage of sodium 40% as determined by the formula $\frac{(Na \times 100)}{(Na+Ca+Mg+k)}$ when the bases are expressed as milli-equivalents per liter	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 100F	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects

cooling water discharge was 4.7 million gallons per day (mgd) with an average temperature of 19.8° C and a maximum value of 25° C. The quality of this effluent is such that it would not have an adverse affect on Portage Creek. Monthly average, maximum, and minimum flow data for this period are included in Table 1-A, located in Appendix A. The location of this outfall and outfalls of all other companies discussed are shown in Figure 1-A of Appendix A.

Georgia Pacific Corporation, Paper Converted Products Plant

This plant, located in Portage, fabricates corrugated containers. The only liquid wastes from the plant consist of sanitary sewage. These wastes are treated by trickling filters, followed by sand filtration, and chlorination before being discharged to Portage Creek.

The monthly operating reports show the plant discharges a small volume (0.007 mgd average) of high quality effluent with an average 5-day biochemical oxygen demand (BOD) concentration of 1.7 milligrams per liter (mg/l.) and an average suspended solids concentration of 2.9 mg/l. This discharge has no measurable effect on the dissolved oxygen resources of the stream.

Allied Paper Incorporated, Monarch and Bryant Divisions

Two divisions of this paper company are located in the south central part of Kalamazoo. The Monarch Division primarily produces carbon tissue using coniferous unbleached pulp that is brought to the plant site. The Bryant Division produces book paper, commercial printing papers, and coated specialty papers. These are produced from hard and softwood sulphate pulp that is brought to the plant site and, until December 1971, with deinked pulp that was produced at the plant site using waste papers.

Historically, both Divisons have diverted water from Portage Creek for use as process and cooling water and have returned their wastewater to the Creek. The polluting materials in these wastewaters consist of oxygen consuming substances (such as starch and binders) and suspended solids (primarily clay and whiteners). In addition residual chlorine bleach wastes from the manufacture of deinked pulp at the Bryant Division were also discharged to the Creek. All of these materials had an extremely adverse effect on the water quality of Portage Creek, and in turn on the water quality of the Kalamazoo River.

The wastewater treatment and reductions provided at these two plants over the last two decades, and particularly in the last few years, has been significant. In October 1951 the Water Resources Commission adopted an Order of Determination on the Monarch Division which declared their existing waste discharge to be 10,100 pounds of BOD per day and 31,900 pounds of suspended solids per day. It added the restriction that all paper processing wastes other than from the deink pulping operation be restricted to not more than ten pounds of suspended solids per ton of paper produced. This Order became effective after October 1, 1953. A Final Order of Determination was adopted by the Commission against the St. Regis Paper Company (now Allied Paper Bryant Division) which declared their existing waste discharge to be 11,100 pounds of BOD per day and 76,500 pounds of

suspended solids per day. This Order also contained the provision that all paper processing wastes other than those from the deink pulping operations be restricted to not more than ten pounds of suspended solids per ton of paper produced. This Order became effective after June 1, 1954. Both mills provided waste solids removal or control facilities as required.

In April 1961 the Commission adopted further restrictions on all paper companies in Kalamazoo, Parchment, Plainwell, and Otsego intended to maintain a minimum dissolved oxygen (DO) content of 30 percent of the saturation value in the Kalamazoo River from Comstock to Allegan at the once in ten year, thirty day drought flow. The Allied Paper Corporations "share" of the allowable maximum waste discharge was a total of 14,490 pounds of BOD per day from all three of their Divisions: Monarch, Bryant, and King (the King Division clarifier discharged to the Kalamazoo River rather than to Portage Creek). In November 1961 a Stipulation containing this limitation was signed by the company. In September 1963 the company indicated that they would proceed independently to construct the facilities to meet this load limit, rather than joining an area wide treatment system. Ultimately, the company met the restriction by discontinuing deinking operations at the Monarch and King Divisions and modifying deinking operations at the Bryant Division. Inplant improvements also reduced the volume of water use and increased efficiency in reclaiming fiber.

While these measures taken by the Company improved water quality of the Kalamazoo River, it did little to improve the water quality of Portage Creek downstream from the Bryant Division. When Intrastate Water Quality Standards were adopted in January 1968, it became necessary to greatly improve wastewater treatment at the Monarch and Bryant Divisions to meet these standards in Portage Creek.

In March 1968 representatives of the company met with the Water Resources Commission to discuss measures necessary to elevate the water quality to satisfactory levels and at the same time were requested to terminate the frequent bypasses of portions of the untreated wastes from the Bryant Division. To achieve these goals, the company has since taken a number of steps. A twelve inch diameter pipeline was constructed from the Bryant Division mills to the Monarch Division clarifier located near Cork Street. White water from both divisions is settled in this clarifier before the supernatent liquid is discharged to Portage Creek. The settled materials are disposed of in large sludge ponds located between the two mills. A portion of the wastes from the Bryant Division (deinking wastes until December 1971) have been discharged to the City of Kalamazoo sewerage system after receiving treatment in the Bryant clarifier. This diversion to the City's system began in September 1969.

Although the early steps greatly reduced the load of waste materials to Portage Creek, the appearance of the creek below Alcott Street appeared virtually unchanged because of the continued discharge of chlorine bleach water from the Bryant Division deinking operation. To solve this problem the company in February 1970 began pumping this waste to the Monarch clarifier along with the Bryant white water. The same month they also discontinued the use of oxidized or chlorinated starch at the Bryant Division and began adding an anionic coagulant to the Monarch clarifier to improve settling.

Deinking operations were terminated at the Bryant Division in December 1971. This is expected to be permanent. A portion of the Bryant Division whitewater is presently being treated in the Bryant clarifier with the final effluent being discharged to the Kalamazoo sewerage system.

Supernatent liquid from the sludge ponds is now reportedly pumped to the City of Kalamazoo sewerage system. This waste was previously discharged to Portage Creek.

In response to a Bureau of Water Management request to identify and eliminate oil reaching Portage Creek from the Bryant Division, the company took several steps. They prevented some oil from reaching the creek by covering fresh water collection tanks under two of their paper machines, built curbs around certain drains, and built a basement sump to collect the power plants' blowdown water from its hot lime soda softener. They also located a drain line from the coating mill that was contributing much of the oil. All of these wastes were added to the whitewaters being pumped to the Monarch clarifier.

Table 2-A of Appendix A lists the waste loads being discharged to Portage Creek from the two Divisions during 1967, 1968 and 1970 Bureau of Water Management surveys. The improvements in wastewater treatments are very evident in the differences in pre-improvement waste loads (1967 and 1968) and the values found after improvements (1970).

The summation of data submitted in monthly operating reports from May through December 1971 is included in Table 1-A of Appendix A. This data shows that the Monarch clarifier discharged an average of 3.759 mgd. The average BOD load was 1,525 pounds per day and the average suspended solids load was 454 pounds per day.

Cadillac Plastic and Chemical Company, Division of Dayco Corporation

This company, located in Kalamazoo a short distance southeast of the central business district, formulates acrylic plastic. Although some product shaping is done most of the production consists of making extrusion stock for other companies.

On September 15 - 17, 1970 two sets of composite samples were collected from the company's two wastewater outfalls to Portage Creek by the staff of the Bureau of Water Management. Analyses of the samples revealed that the company was discharging oils and chloroform extractable materials in quantities sufficient to cover the surface of Portage Creek and that their effluents also contained substantial quantities of suspended solids and BOD. The majority of all constituents were discharged by the south sewer while the north sewer discharged essentially clear cooling water. The waste loads found during these surveys are listed in Table 3-A of Appendix A.

Subsequent Commission action resulted in a Stipulation which was adopted at the August 1971 meeting of the Water Resources Commission. The company agreed to the following terms:

1. Commencing July 1, 1972, and continuing thereafter, the Company will treat or control its wastes to the extent that, when discharged to the waters of the state they shall:

   a. Contain not more than thirty-five (35) milligrams per liter of 5-day BOD.

   b. Contain not more than thirty-five (35) milligrams per liter of suspended solids.

   c. Contain not more than ten (10) milligrams per liter of chloroform extractable substances nor create a noticeable oil film on the receiving waters.

   d. Have a pH of not more than 9.5 nor less than 6.5.

   e. Contain no substances in amounts which are or may become injurious to designated uses of Portage Creek and the Kalamazoo River.

2. The Company shall provide facilities capable of treating and controlling its waste discharges as specified in paragraphs 1 (a), 1(b), 1(c), 1(d), and 1(e), above in accordance with the following time schedule:

   a. Submit complete construction plans and specifications for the necessary treatment facilities to the Chief Engineer of the Commission and obtain his approval thereof on or before October 1, 1971.

   b. Award contracts and commence construction of said facilities on or before October 15, 1971.

   c. Complete construction of facilites and place same into continuous operation on or before July 1, 1972.

The Stipulation stated that if the company planned to correct its pollution of Portage Creek and the Kalamazoo River by connecting its process wastes to the City of Kalamazoo sanitary sewerage system, it was to notify the Commission of this intent by July 1, 1971 and complete its connection to the sewerage system by November 1, 1971. The company has selected this means of correcting its problem and the south sewer effluent (the strong wastes) now receives pretreatment and is discharged to the Kalamazoo sanitary sewer system. The company's north sewer effluent is essentially clear, cooling water which meets all of the restrictions of 1(a) through 1(e) of the Stipulation. It will continue to be discharged to Portage Creek. The company must submit monthly operating reports showing the daily quantity, pH, temperature, and oil-grease severity of this discharge.

WATER QUALITY INVESTIGATIONS

The upper portion of Portage Creek is a clear, attractive stream. Water quality is good. In contrast, the lower three miles have had extremely poor water quality.

Water quality investigations of the lower portion of the stream were conducted in August 1968 and in September 1970 to determine the severity of the problem, to establish the relationship between water quality and waste loads, to determine the degree of improvement in water quality resulting from Allied Paper's improved wastewater treatment practices and to determine the extent of further improvements necessary to protect existing or future use designations.

Sampling Procedures

Six sampling stations were selected in 1968 and seven in 1970 to characterize the water quality of the lower portion of Portage Creek. The locations of these stations are shown in Figure 2.

Nine samples were collected at each location during the 24 hours of the 1968 survey and eight samples during the 24 hours of the 1970 survey. The water temperature of each sample was recorded and the DO concentration, BOD concentration and bacteriological density of each sample was determined in the Lansing laboratories of the Bureau of Water Management and the Michigan Department of Public Health. The results of these analyses for the 1968 survey are listed in Table 1-B and for the 1970 survey in Table 2-B of Appendix B.

Composite samples were made for each station, using portions of the individual samples collected during each sampling run. These composite samples were then analyzed for a number of chemical constituents to indicate water quality during each sampling period. The results of the analyses for the 1968 survey are listed in Table 3-B of Appendix B. The results of the analyses for the 1970 survey are listed in Table 4-B of Appendix B. Two sets of composite samples were accumulated at each station during the 1970 survey; the first set consists of samples collected during the first eighteen hours of the survey in dry weather and the second set consists of samples collected during and after a brief, but heavy, thunder shower.

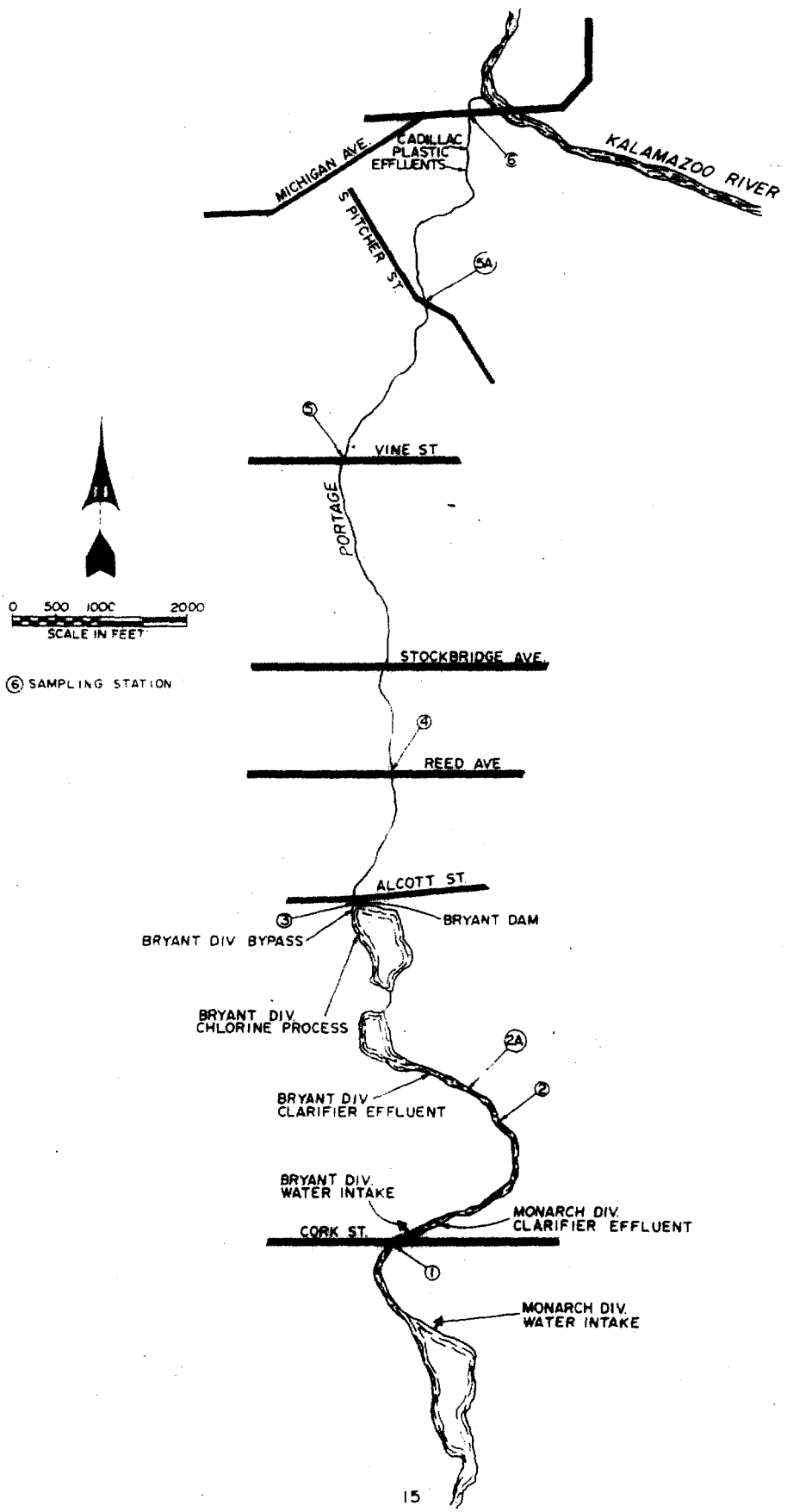
In addition to the two intensive sampling surveys, monthly grab samples were collected prior to Allied Paper's improvements in wastewater treatment. The results of analyses of these samples are listed in Table 5-B.

Physical Appearance

During both investigations, Portage Creek at Cork Street in Kalamazoo was a fast moving, clear stream with a gravel and rock bottom. The Creek was turbid and discolored immediately downstream from the outlet of the Monarch Division clarifier. Sludge deposits were observed on the bottom of the stream between the clarifier outlet and the Bryant Dam.

FIGURE 2

SAMPLING STATION LOCATIONS ON PORTAGE CREEK IN KALAMAZOO 1968 AND 1970 SURVEYS



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In 1968, gas evolution and odors of decomposition were noted in the upper portions of the Bryant millpond and strong chlorine odors were noted near the dam. On occasion, an unsightly grey foam covered portions of the impoundment. The grey, turbid appearance persisted to the Kalamazoo River. Oil was frequently observed downstream from the Bryant Division. Very large quantities of irridescent oil films were usually observed downstream from the Cadillac Plastic and Chemical Company.

In 1970, the appearance of the stream was greatly improved, particularly in the lower reaches. Portage Creek was more turbid below the Monarch clarifier outlet than at Cork Street, however the turbidity had been reduced so that the bottom, which was not visible in 1968, was visible in 1970. Strong odors were not evident. Fish were observed in 1970. Oil was not observed below Allied Paper but was still present near the mouth of the Creek.

Dissolved Oxygen

Sufficient quantities of dissolved oxygen are essential for a healthy stream environment. During both surveys the DO concentrations within the Bryant millpond were not sufficient to even protect the warm tolerant fish use designation. The Intrastate Water Quality Standards state that to protect this use, the average daily DO should not be less than 4 mg/l nor shall any single value be less than 3 mg/l. During the 1968 survey the average DO at the Bryant Dam was only 1.6 mg/l while eight of the nine samples collected had concentration less than 3 mg/l. During the 1970 survey the average concentrations at the Bryant Dam was 4.2 mg/l. However, three of the eight samples collected had concentrations less than 3 mg/l.

The improved 1970 conditions were partially due to the reduced organic waste load discharged by Allied Paper Corporation, Bryant Division and partially due to the fact that water temperatures were lower and stream flows slightly higher in 1970 than in 1968.

The 1968 dissolved oxygen profile is illustrated in Figure 1-B and the 1970 profile in Figure 2-B of Appendix B. In both cases a similar pattern is is found. The high DO concentrations found at Cork Street rapidly dropped after waste effluents were added to the stream and sludge demands exerted their influence in the Bryant millpond. The low point of the profile occurred at the upstream face of the Bryant dam. Marked reaeration occurred as water dropped over the approximately twenty-foot high dam. From the dam to the mouth of Portage Creek, a more gradual decline in DO concentrations occurred.

The greatest depression in DO concentrations occurred in the Bryant millpond because of the reduced water velocities in this reach of Portage Creek. This not only allowed a longer period of time for organic wastes to decompose and utilize available oxygen in the process, but allowed much of the suspended material to settle to the bottom of the impoundment where it added to previously deposited sludge and continued to decompose and utilize oxygen. In addition, supernatent liquid from sludge ponds imposed another source of organic wastes on this reach of the creek.

Biochemical Oxygen Demand

BOD is a measure of the amount of oxygen required by bacteria and other organisms as they decompose the organic matter present in the water. During both the 1968 and 1970 surveys, concentrations at Cork Street were low, 1.7 mg/l and 2.3 mg/l, respectively. In 1968 concentrations approximately doubled below the Monarch clarifier to 3.2 mg/l while in 1970 they increased sixfold to more than 13.9 mg/l; in 1970 the Monarch clarifier was treating both the Monarch and Bryant Division whitewater. In 1968 the BOD concentrations were much higher downstream from the Bryant Dam. A comparison of average BOD concentrations found during the two surveys is presented graphically in Figure 3-B of Appendix B.

Solids

Total solids, suspended solids and suspended volatile solids all increased significantly below the Allied Paper Corporation in 1968 and 1970. In 1970, however, the majority of the suspended solids and suspended volatile solids found in Portage Creek below the outfall of the Monarch clarifier settled out in the Bryant millpond and did not affect the lower reaches of the stream. A graphical comparison of the 1968 and 1970 solids concentrations is presented in Figure 4-B of Appendix B.

Nutrients

In both 1968 and 1970 the ammonia-nitrogen, nitrate-nitrogen, and soluble ortho-phosphorus concentrations decreased in Portage Creek downstream from the discharges of the Allied Paper Corporation. This occurred because the growth of bacteria and other organisms utilized these chemicals in the formation of their cell material. Paper wastes are deficient in nitrogen and phosphorus compounds.

Total phosphorus concentrations did not change significantly below the Allied Paper Corporation.

Other Chemical & Physical Parameters

Calcium, magnesium, and iron concentrations and hardness were not significantly influenced by the Allied Paper Corporation effluents during the 1968 survey. Concentrations of sodium, potassium, chlorides and sulfate were increased by these effluents (see Table 3-B). pH values dropped from 7.7 at Cork Street to 7.1 at the Bryant dam.

In contrast, in 1970 sodium and chloride concentrations were only slightly increased by the Allied Paper Corporation effluent (see Table 4-B). pH values dropped from 8.2 at Cork Street to 7.8 at the Bryant dam. Turbidity, which was not measured in 1968, showed a great increase in Portage Creek downstream from the Monarch clarifier effluent.

Bacterial Densities

Total and fecal coliform bacteria are indicator organisms whose presence

indicates the possible presence of pathogenic (disease causing) bacteria or viruses. Coliform bacteria, which are normally present in the intestinal tracts of humans and other warm-blooded animals, are excreted in large numbers in fecal wastes. Coliform bacteria are also present in soils and on plants. Fecal coliform bacteria provide positive correlation with recent contamination from the fecal material of warm-blooded animals. The presence of coliform bacteria above certain limits is a warning of potential health hazards to those who use the water for direct contact recreation or other purposes.

Michigan's Intrastate Water Quality Standards to protect the designated uses of Portage Creek state that for total coliform organisms per 100 ml, "the geometric average of any series of 10 consecutive samples shall not exceed 5,000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average per 100 ml for the same 10 consecutive samples shall not exceed 1,000".

Total coliform densities fluctuated greatly in the lower portion of Portage Creek. In 1968 coliform densities in Portage Creek were sharply reduced immediately downstream from the discharge of the chlorine bleach wastes. A gradual return to higher densities occurred further downstream (see Table 1-B). In 1970 this reduction did not occur because the chlorine bleach wastes were no longer discharged to Portage Creek from the Bryant Division.

Geometric average fecal coliform densities were less than 1,000 per 100 ml at all sampling stations during both surveys.

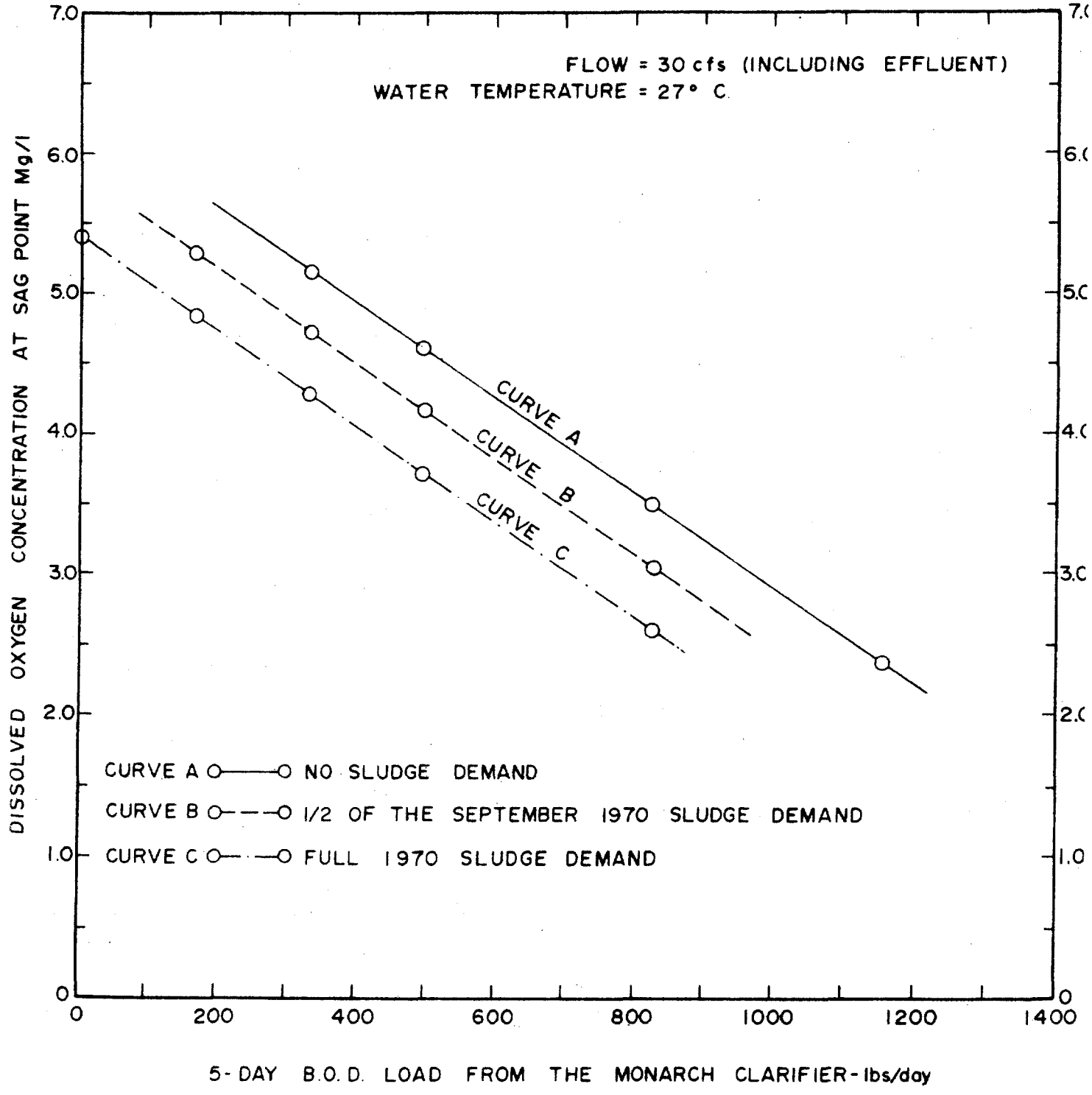
WASTE ASSIMILATION CAPACITY

If the quantities of organic wastes discharged to a stream are limited, the wastes can be assimilated (naturally purified) without impairing legitimate water uses. Assimilation occurs when bacteria and other organisms break down organic or other biodegradable materials into stable compounds or elements. The organisms utilize dissolved oxygen from the water during this process. When excessive quantities of waste are discharged to a stream, oxygen is used faster than it can be replaced by atmospheric reaeration or photosynthesis, and oxygen depletion occurs. Lowered oxygen levels have a measured effect on fish and other aquatic life. A complete lack of dissolved oxygen causes undesirable conditions such as noxious odors and the death of fish and other aquatic life. Low levels change the aquatic environment so that it will support only the least desirable species.

The relationships involved in organic waste assimilation and the rates of oxygen utilization and reoxygenation can be approximated by the use of mathematical models. These relationships and rates are dependent on factors such as the character of waste, the physical characteristics of the stream, flow volumes, the water temperatures, etc. Calculations for Portage Creek using waste load and stream conditions measured during the 1968 and 1970 surveys and assumed decomposition rates, showed that much of the oxygen depletion in the Bryant millpond was due to decomposition of bottom sludges.

FIGURE 3

PREDICTED MINIMUM DISSOLVED OXYGEN CONCENTRATIONS IN PORTAGE CREEK BELOW THE MONARCH CLARIFIER EFFLUENT



Dissolved oxygen concentrations were then predicted for drought flow conditions. Since droughts are most apt to occur in late summer in Michigan, it was assumed that the water temperature would be higher than the 1970 survey conditions. The creek upstream from the Monarch clarifier effluent was assumed to be 90 percent saturated with dissolved oxygen and contain 2.3 mg/l of BOD. Variable waste loads from the Monarch clarifier were selected and assumed to have a K_1 rate of 0.10. The results of three sets of calculations are presented graphically in Figure 3.

For case 1 it was assumed that the same sludge demand as was determined for the September 1970 survey would be present in Portage Creek. To maintain a minimum average DO of 4.0 mg/l (necessary to protect existing use designations) it was found that the Monarch clarifier effluent would have to be limited to 415 pounds per day of BOD. If upgraded use designations are considered (Warm Water Intolerant Fish), the BOD in the effluent would have to be limited to 125 pounds per day to maintain a minimum average DO of 5.0 mg/l under the conditions of these assumptions. See curve C of Figure 3.

For case 2 the most optimistic set of assumptions was made; there would no longer be any sludge addition or demand from previously deposited sludge. When calculations were made using these assumptions, it was found that to maintain a minimum average DO of 4.0 mg/l the effluent would have to be limited to 675 pounds of BOD per day and to maintain a minimum average DO of 5.0 mg/l it would have to be limited to 385 pounds of BOD per day. See curve A of Figure 3.

Actually, it is expected that the existing accumulations of sludge deposits will continue to have some oxygen demand for some years to come. It is also likely that even improved wastewater treatment will still result in an effluent containing some settleable solids. Because of these facts, it was felt that neither Case 1 nor Case 2 would be apt to accurately reflect conditions in Portage Creek after improvements in wastewater treatment. Consequently, a third case was examined; one in which half the sludge demand found in September 1970 was assumed to be present. Calculations using this assumption showed that to maintain a minimum average DO of 4.0 mg/l the effluent would have to be limited to 545 pounds of BOD per day and to maintain a minimum DO of 5.0 mg/l the effluent would have to be limited to 255 pounds of BOD per day. See Curve B of Figure 3.

APPENDIX A

WASTE DISCHARGES

TABLE 1-A

1971 INDUSTRIAL WASTE DISCHARGES TO PORTAGE CREEK (FLOW, BOD, & SUSPENDED SOLIDS)
(DATA FROM MONTHLY OPERATING REPORTS SUBMITTED BY THE COMPANIES)

		5/71	6/71	7/71	8/71	9/71	10/71	11/71	12/71	1971 Averages
Allied Paper Corp., Monarch Clarifier (390006)										
Flow (mgd)	Av.	3.832	3.776	3.830	3.871	3.780	3.728	3.609	3.644	3.759
	Max.	4.216	4.113	4.216	4.216	4.113	4.013	4.113	3.914	
	Min.	3.434	3.341	2.611	3.528	3.340	3.434	2.788	3.247	
BOD (lbs/day)	Av.	1900	1841	1543	1115	1381	1309	1519	1594	1525
	Max.	2900	2800	2900	1900	2000	2200	2500	2200	
	Min.	1000	1200	400	500	500	600	1000	1000	
Susp. Solids (lbs/day)	Av.	560	695	348	590	484	318	383	250	454
	Max.	2300	1800	1300	1900	1270	900	1000	1100	
	Min.	0	0	0	0	0	0	0	0	
Upjohn Co. (390055)										
Flow (mgd)	Av.	----	----	5.96	6.68	5.45	4.28	2.41	3.40	4.70
	Max.	----	----	8.18	11.09	8.90	6.97	5.34	8.62	
	Min.	----	----	3.05	2.67	1.47	1.00	1.09	1.17	
Georgia-Pacific Corp, Portage Paper Converted Prod. Plt. (390065)										
Flow (mgd)	Av.	----	----	----	----	0.007	0.007	0.006	----	0.007
	Max.	----	----	----	----	0.008	0.008	0.008	----	
	Min.	----	----	----	----	0.005	0.005	0.005	----	
BOD (mg/l)	Av.	----	----	----	----	1.6	1.4	2.0	----	1.7
	Max.	----	----	----	----	2.0	2.1	4.0	----	
	Min.	----	----	----	----	1.0	1.0	1.0	----	
Susp. Solids (mg/l)	Av.	----	----	----	----	1.9	2.2	4.5	----	2.9
	Max.	----	----	----	----	4.0	4.0	7.0	----	
	Min.	----	----	----	----	1.2	1.3	2.0	----	

FIGURE I-A

MAJOR WASTEWATER DISCHARGES TO PORTAGE CRE

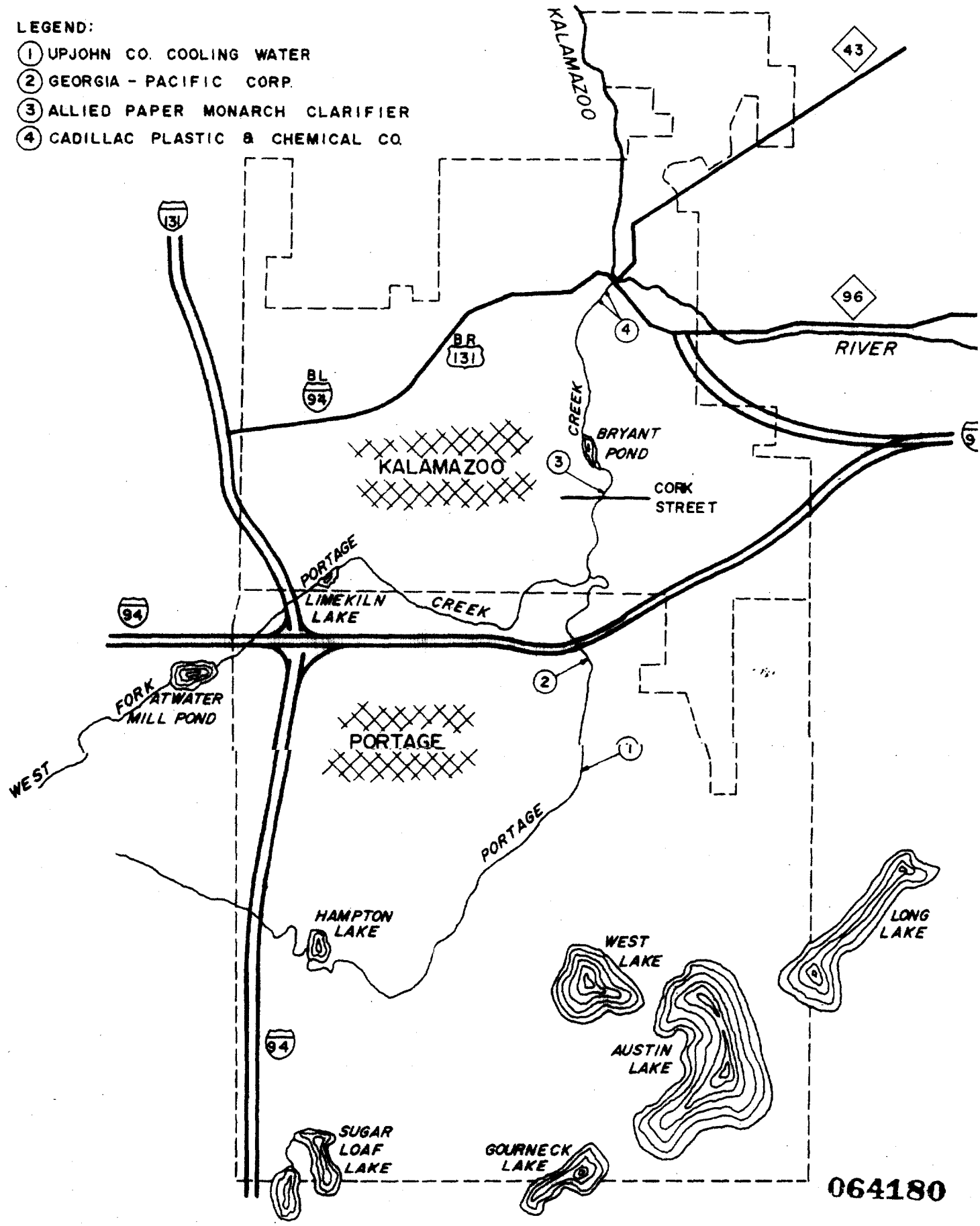


TABLE 2-A

WASTE LOAD DISCHARGES (LBS./DAY) TO PORTAGE CREEK FROM ALLIED PAPER, INC., MONARCH AND BRYANT DIVISIONS

MONARCH DIVISION

Parameter	6/13-14/67	6/14-15/67	6/4-5/68	6/5-6/68	8/20-21/68	9/16-17/70***
5-day BOD	568	202	586	712	456	1,636
COD	----	----	870	1423	----	2,383
Total Solids	----	----	----	----	9,026	16,076
Susp. Solids	497	248	391	538	564	1,608
Susp. Vol. Solids	231	186	249	411	304	1,608
Settleable Solids	391	171	213	221	----	----
Total PO_4-P	----	----	7	20	----	3
Sol. Ortho PO_4P	----	----	0	0	----	0
Organic Nitrogen-N	----	----	37	52	----	43
Ammonia Nitrogen-N	----	----	7	0	----	0
Nitrate Nitrogen-N	----	----	0	0	----	6
Sodium	----	----	----	----	----	976
Sulfates	----	----	----	----	----	4,306
Chlorides	----	----	----	----	----	1,263
Flow (mgd)	2.128	1.86	2.127	1.895	2.6	3.44

BRYANT DIVISION

	*	*				
5-day BOD	11,193	6,870	7,559	8,036	10,008	Discharge
COD	----	----	13,608	16,801	----	included
Total Solids	----	----	5,550**	5,676**	46,904	in that
Susp. Solids	8,155	6,126	3,434	5,658	6,712	shown above.
Susp. Vol. Solids	2,958	1,775	1,638	2,911	2,425	
Settleable Solids	680	458	1,163	3,638	----	
Total PO_4-P	----	----	33	54	----	
Sol. Ortho PO_4-P	----	----	6	9	----	
Organic Nitrogen-N	----	----	116	147	----	
Ammonia Nitrogen-N	----	----	0	0	----	
Nitrate Nitrogen-N	----	----	1	3	----	
Sodium	----	----	----	----	----	
Aluminum	----	----	----	----	101	
Sulfates	----	----	----	----	----	
Chlorides	----	----	----	----	----	
Chloroform Extr.	----	----	508	710	----	
Flow (mgd)	4.79	3.43	3.402	3.602	3.91	

NOTE: (1) All data is from analyses of composite samples collected during surveys of the plants conducted by the Bureau of Water Management.

(2) All loads are expressed as pounds per day except Flow which is in million gallons per day.

* Only the Bryant clarifier discharge; does not include deinking bleach wastewater, or bypasses, if any.

** Only the deinking bleach wastewater contribution

*** White water from both the Monarch and Bryant Divisions treated in this clarifier.

TABLE 3-A

WASTE LOAD DISCHARGES (LBS./DAY) TO PORTAGE CREEK
FROM THE CADILLAC PLASTIC AND CHEMICAL COMPANY

	North Sewer	
Parameter	9/16-17/70	9/17/70
5-day BOD	3	1
Susp. Solids	6	11
Susp. Vol. Solids	5	8
Total PO_4-P	0.2	0.2
Mercury	0	0
Chloroform Extr.	2	1
Flow (mgd)	0.044	0.044

	South Sewer	
5-day BOD	26	216
Susp. Solids	272	3,152
Susp. Vol. Solids	152	2,324
Total PO_4-P	0.1	0.3
Mercury	0	0
Chloroform Extr.	280	1,554
Flow (mgd)	0.034	0.055

NOTE: All loads are expressed as pounds per day except flow which is in million gallons per day.

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APPENDIX B

WATER QUALITY INVESTIGATIONS

TABLE 1-B

RESULTS OF ANALYSES OF 1968 GRAB SAMPLES OF PORTAGE CREEK

Sampling Stations	Date	Time	Temp. (°C)	K_1 Rate	Dissolved Oxygen (mg/l)	5-day BOD (mg/l)	Total Coliform Organisms (counts/100 ml)	Fecal Coliform Organisms (counts/100 ml)
1. Cork Street	8/20	0800	23	0.09	7.4	1.6	10,000	100
	8/20	1040	23	----	7.6	1.9	1,400	700
Mile Point 3.04	8/20	1320	24	----	7.6	1.8	900	500
	8/20	1552	26.5	----	7.4	1.6	4,000	400
	8/20	1850	26	----	7.2	1.4	4,000	200
	8/20	2114	26	----	7.6	2.0	8,000	300
	8/20	2350	25	----	7.2	1.4	6,000	190
	8/21	0240	25	----	7.4	2.0	18,000	600
	8/21	0520	24	----	7.6	1.9	11,000	20
	Arithmetric Ave.		24.7		7.4	1.7	7,000	334
	Geometric Ave.		----		7.4	1.7	4,989	232
2. End of sludge pond between Cork and Alcott Streets	8/20	0817	25	----	6.1	3.7	6,000	600
	8/20	1056	25.5	----	6.4	2.9	1,000	700
	8/20	1332	26	----	6.2	3.0	7,800	360
Mile Point 2.58	8/20	1610	27	----	6.6	3.0	400	130
	8/20	1858	27	----	6.6	2.8	8,000	300
	8/20	2127	27	----	6.2	3.2	11,000	600
	8/21	0005	26	----	6.4	3.2	19,000	200
	8/21	0255	26	----	6.0	3.6	18,000	200
	8/21	0530	26	----	5.6	3.6	15,000	20
	Arithmetric Ave.		26.2		6.2	3.2	9,600	345
	Geometric Ave.		----		6.2	3.2	5,884	263
3. Byrant Dam	8/20	0829	25.5	0.13	1.6	27.0	400	10
	8/20	1110	26	----	1.2	23.0	< 100	< 10
Mile Point 1.94	8/20	1344	27	----	1.0	30.0	< 100	< 10
	8/20	1614	28	----	2.6	23.0	3,400	< 10
	8/20	1908	29	----	0.6	32.0	1,100	130
	8/20	2133	28	----	3.0	----	< 100	< 10
	8/21	0015	28	----	1.6	29.0	< 100	50
	8/21	0305	28	----	1.4	33.0	< 100	< 10
	8/21	0540	27	----	1.0	41.0	< 100	10
	Arithmetric Ave.		27.4		1.6	29.8	< 611	< 25
	Geometric Ave.		----		1.4	29.3	< 225	< 16
4. Reed Avenue	8/20	0837	25.5	----	7.2	32.0	< 100	< 10
	8/20	1121	26	----	7.4	32.0	< 100	< 10
Mile Point 1.63	8/20	1352	27	----	6.8	29.0	< 100	< 10
	8/20	1620	28	----	6.8	31.0	< 100	< 10
	8/20	1911	28	----	6.2	38.0	130,000	8,000
	8/20	2139	28	----	6.0	37.0	240,000	< 10
	8/21	0025	26	----	6.6	33.0	800	10
	8/21	0310	27	----	6.8	34.0	< 100	< 10
	8/21	0545	28	----	7.0	30.0	< 100	< 10
	Arithmetric Ave.		27.1		6.8	32.9	< 41,267	< 879
	Geometric Ave.		----		6.7	32.8	< 664	< 21
5. Vine Street	8/20	0848	25.5	----	6.4	33.0	70,000	1,000
	8/20	1130	26	----	6.4	30.0	< 100	< 10
Mile Point 0.94	8/20	1400	27	----	6.2	28.0	500	70
	8/20	1625	28	----	6.0	32.0	29,000	130
	8/20	1920	28	----	4.6	38.0	20,000	2,100
	8/20	2147	27.5	----	5.6	38.0	110,000	7,000
	8/21	0035	26	----	5.8	35.0	8,800	< 10
	8/21	0315	27	----	6.2	34.0	900	50
	8/21	0555	27	----	6.4	33.0	30,000	50
	Arithmetric Ave.		27.0		6.0	33.4	< 29,922	< 1,158
	Geometric Ave.		----		5.9	33.3	< 4,089	< 148
6. Michigan Avenue	8/20	0858	25	0.12	5.2	33.0	1,500	< 10
	8/20	1145	26	----	5.0	30.0	14,500	430
Mile Point 0.06	8/20	1410	26.5	----	5.0	21.0	20,700	630
	8/20	1637	27	----	4.6	32.0	400,000	38,000
	8/20	1928	27	----	4.2	33.0	84,000	1,900
	8/20	2155	27	----	4.0	37.0	160,000	2,000
	8/21	0040	26	----	4.0	51.0	150,000	6,000
	8/21	0330	27	----	4.0	35.0	80,000	1,000
	8/21	0605	26	----	4.0	35.0	11,000	80
	Arithmetric Ave.		26.4		4.4	34.1	113,411	< 5,561
	Geometric Ave.		----		4.4	33.3	40,888	< 830

NOTE: Field dissolved oxygen saturation at 23°C = 8.2 mg./l. at sampling station #1.

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TABLE [illegible]

RESULTS OF ANALYSES OF 1970 GRAB SAMPLES OF PORTAGE CREEK

Sampling Stations	Date	Time	Temp. (°C)	D.O. (mg./l.)	B.O.D. (mg./l.)	pH	Total Coliform Bacteria (counts/100 ml.)	Fecal Coliform Bacteria (counts/100 ml.)
1 Cork Street Mile Point 3.04	9/16/70	1800	18.5	8.6	1.7	8.0	2,000	90
	9/16/70	2100	18.0	8.6	1.8	8.4	2,000	180
	9/17/70	2400	18.0	8.6	1.8	8.3	2,000	100
	9/17/70	0300	17.0	8.5	2.1	7.9	28,000	200
	9/17/70	0600	16.0	8.4	1.6	8.3	23,000	900
	9/17/70	0900	16.0	9.4	2.9	---	5,000	180
	9/17/70	1200	15.0	10.8	4.2	---	33,000	910
	9/17/70	1500	16.5	9.4	2.6	---	4,800	100
	Arithmetric Ave.		16.9	9.0	2.3	8.2	12,475	332
	Geometric Ave.		---	9.0	2.2	---	6,703	216
2A 2,100 ft. downstream from Monarch Clarifier discharge, 300 ft. downstream from end of sludge pond. Mile Point 2.50	9/16/70	1810	21.0	5.2	>13.2	7.9	4,000	<10
	9/16/70	2110	21.0	6.0	12.4	7.8	6,000	<100
	9/17/70	0005	21.0	5.2	>13.2	8.0	4,000	100
	9/17/70	0310	19.0	6.4	>14.4	7.7	58,000	100
	9/17/70	0605	18.0	6.8	12.8	8.1	4,000	100
	9/17/70	0915	18.5	8.0	>16.0	---	10,000	2,500
	9/17/70	1215	18.0	7.4	13.0	---	130,000	20,000
	9/17/70	1511	19.5	8.0	>16.0	---	120,000	12,000
	Arithmetric Ave.		19.5	6.6	>13.9	7.9	42,000	<4,364
	Geometric Ave.		---	6.5	>13.4	---	15,592	<395
3 Bryant Dam Mile Point 1.94	9/16/70	1820	21.0	5.2	9.6	8.0	20,000	30
	9/16/70	2120	21.0	4.4	9.2	7.7	10,000	300
	9/17/70	0010	21.0	3.6	10.0	7.5	10,000	100
	9/17/70	0335	18.0	2.8	9.2	7.7	18,000	100
	9/17/70	0620	18.5	2.4	8.0	7.8	7,000	<100
	9/17/70	0930	18.0	2.6	9.2	---	31,000	700
	9/17/70	1230	18.5	4.4	9.4	---	37,000	1,200
	9/17/70	1520	19.0	8.2	10.4	---	31,000	3,000
	Arithmetric Ave.		19.4	4.2	9.3	7.7	20,500	<2,041
	Geometric Ave.		---	3.9	9.2	---	17,541	<262
4 Reed Avenue Mile Point 1.63	9/16/70	1825	21.0	7.8	10.6	8.1	9,000	200
	9/16/70	2130	20.0	7.8	10.6	7.9	19,000	500
	9/17/70	0015	20.0	7.8	9.8	7.8	24,000	100
	9/17/70	0345	19.0	8.0	8.8	8.1	30,000	100
	9/17/70	0625	18.5	7.8	7.8	8.2	14,000	100
	9/17/70	0940	18.5	8.6	8.6	---	7,900	260
	9/17/70	1240	18.5	8.8	9.2	---	25,000	1,200
	9/17/70	1530	19.5	9.6	9.4	---	73,000	8,500
	Arithmetric Ave.		19.4	8.3	9.4	8.0	25,238	1,370
	Geometric Ave.		---	8.2	9.3	---	19,976	476
5 Vine Street Mile Point 0.94	9/16/70	1835	21.0	7.0	13.4	8.0	2,000	40
	9/16/70	2140	21.0	6.8	9.2	8.0	9,000	<100
	9/17/70	0020	20.0	4.8	5.2	7.8	6,000	100
	9/17/70	0355	19.0	6.8	7.6	8.1	14,000	100
	9/17/70	0635	18.5	6.9	8.1	8.2	10,000	200
	9/17/70	0953	18.5	7.8	8.4	---	16,000	900
	9/17/70	1253	19.0	8.2	8.6	---	17,000	1,800
	9/17/70	1543	19.5	4.8	4.6	---	30,000	2,600
	Arithmetric Ave.		19.6	6.6	8.1	8.0	13,000	<730
	Geometric Ave.		---	6.6	7.7	---	10,264	<276
6 S. Pitcher St. Mile Point 0.31	9/16/70	1840	21.0	5.6	>13.6	8.1	340,000	1,600
	9/16/70	2145	21.0	6.4	8.8	7.8	14,000	400
	9/17/70	0025	20.0	6.4	8.8	7.7	11,000	400
	9/17/70	0410	19.0	6.2	7.6	8.2	19,000	300
	9/17/70	0640	18.0	6.4	7.2	8.2	15,000	800
	9/17/70	1005	18.5	7.4	7.8	--	26,000	980
	9/17/70	1305	19.0	6.6	7.4	---	9,000	600
	9/17/70	1551	19.5	6.4	5.2	---	10,000	1,300
	Arithmetric Ave.		19.5	6.4	>8.3	8.0	55,500	798
	Geometric Ave.		---	6.4	>8.0	---	20,785	682
7 Michigan Avenue Mile Point 0.06	9/16/70	1845	22.5	5.8	9.0	8.0	15,000	100
	9/16/70	2150	20.0	5.6	8.0	7.7	11,000	400
	9/17/70	0030	20.0	5.8	7.4	7.6	27,000	400
	9/17/70	0420	19.0	5.9	7.1	8.0	19,000	200
	9/17/70	0650	18.5	6.0	6.0	8.2	20,000	100
	9/17/70	1020	18.0	6.6	7.4	---	25,000	560
	9/17/70	1316	18.5	7.2	9.6	---	31,000	1,300
	9/17/70	1602	20.0	10.0	10.2	---	19,000	2,200
	Arithmetric Ave.		19.6	6.6	8.1	7.9	20,875	658
	Geometric Ave.		---	6.5	8.0	---	19,933	388

TABLE 3-B

RESULTS OF ANALYSES OF 1968 COMPOSITE SAMPLES OF PORTAGE CREEK

Analysis	Sampling Stations: Cork Street 1	End of Sludge Pond 2	Bryant Dam 3	Reed Avenue 4	Vine Street 5	Michigan Avenue 6
Total Solids	348	358	502	472	486	506
Suspended Solids	12	25	55	41	51	46
Suspended Volatile Solids	3	16	20	14	23	14
pH	7.7	7.4	7.1	7.3	7.3	7.3
Ammonia - N	0.1	0.1	0.2	0.0	0.0	0.0
Nitrate - N	0.50	0.40	0.10	0.10	0.0	0.0
Soluble Ortho PO_4-P	0.06	0.02	0.0	0.0	0.0	0.0
Total PO_4-P	0.15	0.19	0.26	0.18	0.26	0.25
Hardness	230	230	230	230	230	260
Calcium	64	64	62	62	62	70
Magnesium	17	17	18	18	18	21
Sodium	9.2	12	37	34	33	37
Potassium	0.8	0.9	1.8	1.6	1.6	1.8
Iron	0.5	0.7	0.6	0.5	0.6	0.6
Chloride	18	20	50	40	40	50
Sulfate	36	40	56	54	52	58

NOTE: All constituents except pH are expressed as mg./l.

Survey Period from 0800, August 20, 1968 to 0800, August 21, 1968

Average Flow upstream from Cork St. = 33.7 cfs.
Average Flow at Reed Ave. = 44.0 cfs.

TABLE 4-B

RESULTS OF ANALYSES OF 1970 COMPOSITE SAMPLES OF PORTAGE CREEK

ANALYSIS	SAMPLING STATIONS						
	Cork Street 1	2100 Ft. below Monarch Clarifier 2A	Bryant Dam 3	Reed Avenue 4	Vine Street 5	S. Pitcher Street 5A	Michigan Avenue 6
Total Solids	334	432	370	366	376	384	394
Suspended Solids	14	80	12	12	14	15	13
Suspended Vol. Solids	6	22	4	5	5	5	6
pH	8.2	8.0	7.8	7.8	7.9	8.0	8.0
Turbidity (J.C.U.)	4	18	12	12	13	11	11
Ammonia - N	0.19	0.13	0.07	0.07	0.04	0.02	0.05
Nitrate - N	0.65	0.30	0.30	0.40	0.25	0.30	0.25
Sol. Ortho PO_4-P	0.03	0.00	0.01	0.02	0.02	0.00	0.00
Total PO_4-P	0.07	0.13	0.08	0.08	0.12	0.11	0.09
Sodium	14	18	22	18	18	19	20
Chloride	25	28	28	30	28	32	33
K_1 Rate	Low	0.145	------	0.10	------	------	0.06
Suspended Solids	22	80	17	11	18	14	30
Suspended Vol. Solids	9	10	6	4	4	4	8
pH	8.1	8.0	7.9	7.9	8.0	8.0	7.9
Turbidity (J.C.U.)	9	20	20	12	15	11	14
Ammonia - N	0.11	0.07	0.04	0.09	0.04	0.05	0.05
Nitrate - N	0.70	0.35	0.25	0.30	0.35	0.30	0.35
Sol. Ortho PO_4-P	0.03	0.02	0.03	0.03	0.02	0.04	0.06
Total PO_4-P	0.09	0.20	0.10	0.11	------	------	-------
Chloride	24	28	29	29	29	44	37

NOTE: All constituents except pH, turbidity and K_1 Rate are expressed as mg/l.

Upper, prerain set of data from 1800, Sept. 17, 1970 to 1000, Sept. 18, 1970.
Lower, post rain set of data from 1000, Sept. 18, 1970 to 1800, Sept. 18, 1970.

Average Flow at Reed Avenue = 47.0 cfs.

TABLE 5-B

SEASONAL VARIATIONS OF PORTAGE CREEK WATER QUALITY
PRIOR TO IMPROVEMENTS IN ALLIED PAPER COMPANY'S
WASTEWATER TREATMENT

Sampling Station	Date	Time	Flow (cfs)	Temp. (°C)	Dissolved Oxygen	Susp.	5-Day BOD	K_1 Rate	pH	Total Dissolved Solids	Susp. Solids	Susp. Vol. Solids	NH_3-N	NO_2-N	NO_3-N	Soluble Ortho PO_4-P	Total PO_4-PO_4	Total Coliform (count/100 ml.)	Fecal Coliform (count/100 ml.)	H_2S Sensory
Lovers Lane	9/26/67	1120	40	16.5	8.4	86.1	2.7	---	7.3	---	24	17	---	---	---	---	---	17,000	2,600	---
	4/24/68	1115	61	11	---	---	---	---	7.4	116	---	---	---	---	1.06	---	---	---	---	---
U.S. 31	9/26/67	1130	40	16	8.2	82.6	2.5	---	---	---	19	---	---	---	---	---	---	4,000	500	---
	12/20/67	1112	41	5	11.2	82.5	2.6	0.07	7.4	439	10	7	---	---	---	---	---	---	---	---
	1/23/68	1045	41	1	11.8	82.5	2.6	---	---	446	5	---	< 0.2	---	1.3	0.25	0.28	7,000	900	---
	2/19/68	1040	41	1	13.0	82.6	1.9	---	---	228	10	5	0.0	0.01	0.80	0.25	0.44	30,000	100	---
	3/21/68	1055	43	6	10.8	86.5	2.7	---	7.4	---	25	6	0.0	---	0.90	0.10	0.25	2,100	100	---
	4/26/68	0820	40	7	10.5	86.1	2.1	---	8.0	---	1	---	0.0	---	0.75	0.15	0.35	1,600	200	---
	5/21/68	1105	30	14	9.4	88.2	2.6	---	8.1	214	22	11	0.0	---	0.58	0.10	0.20	1,900	100	0.0
	6/25/68	1411	90	22	7.6	81.8	4.7	---	7.7	265	98	9	0.0	0.01	0.70	0.15	0.24	11,000	500	< 0.1
	7/22/68	1132	55	23	7.5	86.5	4.2	---	7.7	274	88	10	0.2	0.05	0.60	0.10	1.7	46,000	2,200	---
													0.1	0.03	0.70	0.11	0.25	81,000	4,000	---
Allied Paper Co.	9/26/67	1115	---	18	1.9	48.2	48	---	7.6	---	500	170	---	---	---	---	---	< 100	< 100	---
	2/19/68	1135	---	1	10.8	70.4	8	0.17	8.0	28	11	7	0.0		0.30	0.10	0.15	200	100	---
	3/21/68	1110	---	9	9.3	71.6	27	---	8.0	---	33	5	0.0		0.55	0.10	0.40	< 100	< 100	---
	4/26/68	0830	---	8.5	7.8	66.5	41	---	7.9	422	30	11	0.0		0.30	0.08	0.55	< 100	< 100	0.1
	5/21/68	1130	---	16.5	6.8	58.2	19	---	7.5	190	22	14	0.0	0.01	0.00	0.05	0.40	80,000	200	0.1
	6/25/68	1425	---	24	0.5	5.9	35	---	7.2	360	4	24	0.0	0.00	0.00	0.10	0.20	53,000	2,400	---
	7/22/68	1141	---	25	0.4	5.8	21	---	7.2	430	42	14	0.0	0.00	0.00	0.05	0.62	42,000	2,900	---
Reed Ave.	12/20/67	1128	---	8	10.6	89.3	19	0.05	8.0	190	122	38	< 0.2		0.40	0.30	2.3	< 100	< 100	---
	1/23/68	1100	---	5	11.2	87.5	15	---	8.0	160	24	5	0.0	0.00	0.65	0.25	0.50	< 100	< 100	---
	2/19/68	1125	---	2	12.2	88.2	8.6	---	7.9	---	10	4	0.0		1.0	0.15	0.60	< 100	< 100	---
	3/21/68	1120	---	9.5	10.2	89.0	29	---	8.2	---	46	11	0.0		0.70	0.15	0.70	< 100	< 100	---
	4/26/68	0840	---	9	10.0	86.3	46	---	7.9	---	52	13	0.0		0.30	0.00	0.65	< 100	< 100	> 2.0
	5/9/68	1300	---	19	---	---	---	---	7.7	164	---	---	---	---	0.02	---	---	---	---	---
	5/21/68	1144	48	16	8.6	86.4	18	---	7.7	170	13	5	0.0	0.08	0.40	0.00	0.70	18,000	600	< 0.1
	6/25/68	1435	155	24	6.4	75.0	33	---	7.3	414	164	62	0.0	0.02	0.09	0.10	1.3	84,000	2,400	---
	7/22/68	1155	53	26	6.4	77.9	41	---	7.3	450	94	28	0.0	0.00	0.00	0.31	1.12	16,000	6,500	---
Swakhammer Ave.	9/26/67	1145	---	18	7.6	79.2	41	---	7.8	---	172	66	---	---	---	---	---	< 100	< 100	---
Burlingame Ave.	9/26/67	1210	---	18.5	6.6	69.9	40	---	7.6	---	168	60	---	---	---	---	---	800	100	---
	12/20/67	1028	---	7.5	9.6	79.9	44	---	8.1	190	267	158	< 0.2		0.65	0.30	2.4	< 100	< 100	---
	1/23/68	1115	---	5	10.6	82.8	19	---	7.9	170	34	13	0.0	0.02	2.7	0.15	0.95	< 100	< 100	---
	2/19/68	1140	---	2	11.2	80.9	9.9	0.12	8.0	---	10	10	0.0		0.90	0.15	0.60	< 100	< 100	---
	3/21/68	1130	---	9	9.7	83.7	36	---	8.0	---	40	20	0.0		0.65	0.20	1.3	700	< 100	---
	4/26/68	0850	---	9	10.0	86.3	41	---	7.9	190	46	17	0.0	0	0.10	0.00	0.75	< 100	< 100	0.5
	5/21/68	1156	---	16	8.0	80.4	33	---	7.7	194	54	21	0.0	0.00	0.40	0.05	0.70	< 100	< 100	< 0.1
	6/25/68	1450	---	22.5	5.2	59.4	23	---	7.2	420	440	35	0.0	0.00	0.00	0.05	2.5	79,000	5,500	---
	7/22/68	1210	---	25.5	4.0	48.2	21	---	7.3	500	44	26	0.0	0.00	0.00	0.09	1.20	34,000	3,500	---
	9/11-13/68	---	---	18.9	7.1	75.8	49.1	---	7.5	444	49	32	0.0	---	0.10	0.00	1.11	2,400	< 200	---

NOTE: All constituents except K_1 rate, pH and those otherwise designated are expressed as mg./l.

Flows at the first two stations are those recorded at the USGS gage at Lovers Lane
Flows at other stations are those recorded at the WRC gage at Reed Ave.

NO_2 value is included in the NO_3 value.

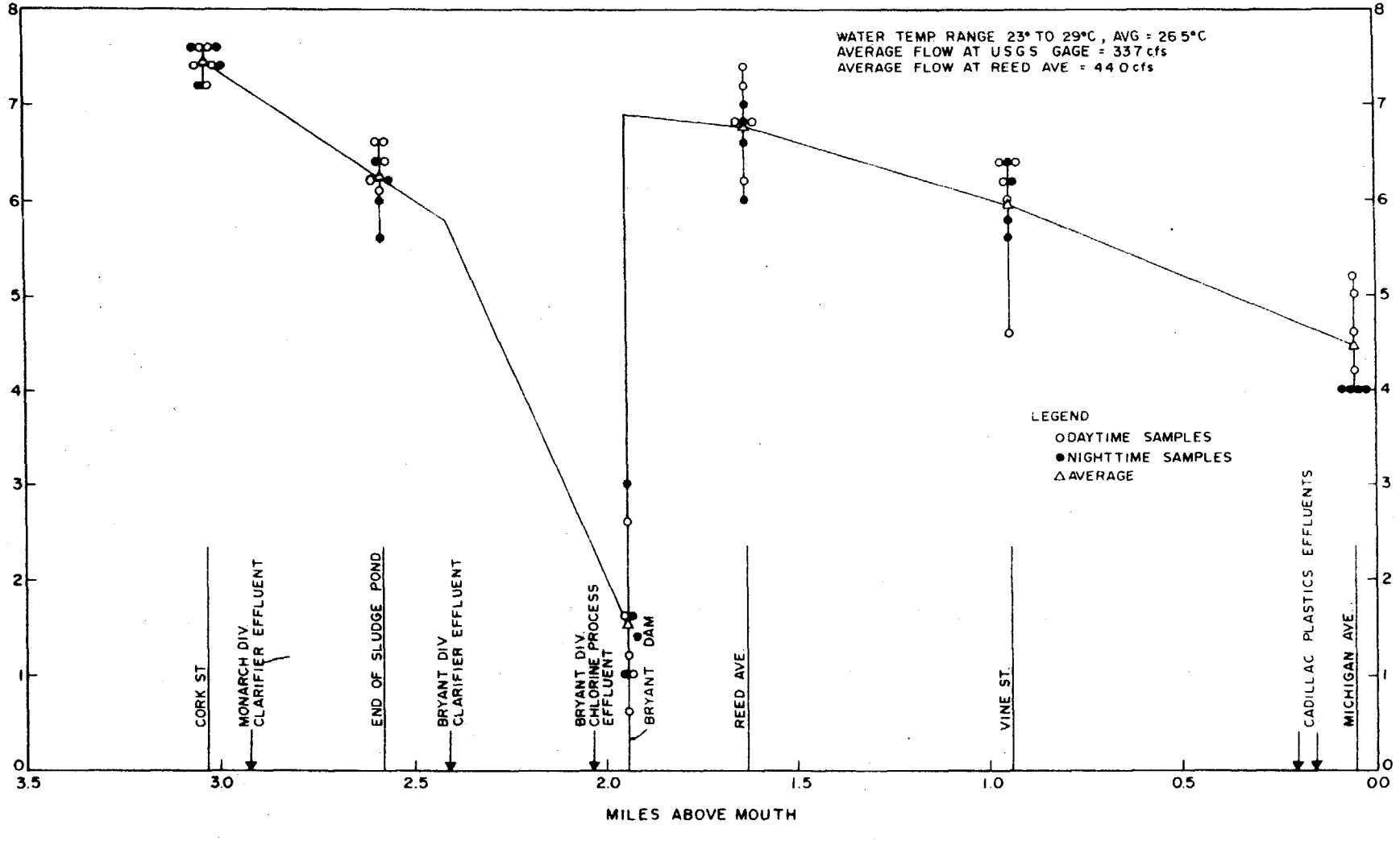
* These values are the means or composites of up to 15 samples collected from 0F00, 9/11/68 to 0F00, 9/13/68
Coliform counts are geometric means.

FIGURE 1-B

PORTAGE CREEK IN KALAMAZOO

DISSOLVED OXYGEN PROFILE

AUGUST 20-21 1968 SURVEY



EPA REGION V

064190 to 064192

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